

Docket No. AUS920030292US1

**METHOD, APPARATUS, AND PROGRAM FOR CODE REUSABILITY AND
MAINTAINABILITY IN XML-DRIVEN PROJECTS**

BACKGROUND OF THE INVENTION

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1. Technical Field:

The present invention relates to data processing systems and, in particular, to building application program interfaces for extensible markup language documents.

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2. Description of Related Art:

Database architectures, such as E-business infrastructures, include large numbers of data entities. These entities may be stored as objects in a data store. The data entities also include large numbers of attributes, which may also be entities. An application program interface (API) may be programmed to access the entities and their attributes.

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However, entities may share common attributes. For example, status may be an attribute of several entities, such as customer, user, server, etc. Thus, developers may need to provide code for accessing entities and their attributes redundantly.

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Furthermore, the database architecture may change. For example, database column names may change or be removed from previous versions. Therefore, a developer may also need to update the API code for every change in the database architecture. The code must also be changed for each entity being affected.

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Docket No. AUS920030292US1

Therefore, it would be advantageous to provide an improved mechanism for code reusability and maintainability in application program interfaces.

Docket No. AUS920030292US1

SUMMARY OF THE INVENTION

The present invention provides a data dictionary that specifies the entities and corresponding attributes for the application program interface developers to use. An extensible markup language interface is provided for customers to perform operations on the data. Application program interfaces receive extensible markup language requests and generate extensible markup language response documents that may return data from the database. The present invention also provides a set of classes that correspond to the entities that are defined in the data dictionary. These classes define utility methods for use in retrieving data. The application program interfaces may call these utility methods, passing an identification of an entity and a string representing extensible markup language element name that the caller wants the extensible markup language response object's name to be. The method call may also pass a list of attributes that should be returned. The application program interface then appends the returned response object at the depth necessary in order to generate an extensible markup language document.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

10 **Figure 1** depicts a pictorial representation of a network of data processing systems in which the present invention may be implemented;

Figure 2 is a block diagram of a data processing system that may be implemented as a server in accordance with a preferred embodiment of the present invention;

Figure 3 is a block diagram illustrating a data processing system in which the present invention may be implemented;

20 **Figure 4** is a block diagram illustrating a database configuration with an XML interface in accordance with a preferred embodiment of the present invention;

Figure 5 is an example implementation in accordance with a preferred embodiment of the present invention;

25 **Figure 6** is a flowchart illustrating the maintenance of an entity in a database infrastructure in accordance with a preferred embodiment of the present invention;

Figure 7 is a flowchart illustrating the operation of an application program interface in accordance with a preferred embodiment of the present invention; and

Docket No. AUS920030292US1

Figure 8 is a flowchart illustrating the operation of a utility method in accordance with a preferred embodiment of the present invention.

Docket No. AUS920030292US1

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures, **Figure 1** depicts a pictorial representation of a network of data processing systems in which the present invention may be implemented. Network data processing system **100** is a network of computers in which the present invention may be implemented. Network data processing system **100** contains a network **102**, which is the medium used to provide communications links between various devices and computers connected together within network data processing system **100**. Network **102** may include connections, such as wire, wireless communication links, or fiber optic cables.

In the depicted example, server **104** is connected to network **102** along with storage unit **106**. In addition, clients **108**, **110**, and **112** are connected to network **102**. These clients **108**, **110**, and **112** may be, for example, personal computers or network computers. In the depicted example, server **104** provides data, such as E-business infrastructure data to clients **108**, **110**, **112**. Clients **108**, **110**, and **112** are clients to server **104**. Network data processing system **100** may include additional servers, clients, and other devices not shown.

In accordance with a preferred embodiment of the present invention, server **104** provides data and services to clients **108**, **110**, **112**. The clients, such as client **108**, may be used by developers to code extensible markup language (XML) requests and application program interface (API) calls. In addition, server **104** exposes XML

Docket No. AUS920030292US1

interfaces for clients to access data and services from server 104.

In the depicted example, network data processing system 100 is the Internet with network 102 representing a worldwide collection of networks and gateways that use the TCP/IP suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers, consisting of thousands of commercial, government, educational and other computer systems that route data and messages. Of course, network data processing system 100 also may be implemented as a number of different types of networks, such as for example, an intranet, a local area network (LAN), or a wide area network (WAN). **Figure 1** is intended as an example, and not as an architectural limitation for the present invention.

Referring to **Figure 2**, a block diagram of a data processing system that may be implemented as a server, such as server 104 in **Figure 1**, is depicted in accordance with a preferred embodiment of the present invention. Data processing system 200 may be a symmetric multiprocessor (SMP) system including a plurality of processors 202 and 204 connected to system bus 206. Alternatively, a single processor system may be employed. Also connected to system bus 206 is memory controller/cache 208, which provides an interface to local memory 209. I/O bus bridge 210 is connected to system bus 206 and provides an interface to I/O bus 212. Memory controller/cache 208 and I/O bus bridge 210 may be integrated as depicted.

Docket No. AUS920030292US1

Peripheral component interconnect (PCI) bus bridge 214 connected to I/O bus 212 provides an interface to PCI local bus 216. A number of modems may be connected to PCI local bus 216. Typical PCI bus implementations will support four PCI expansion slots or add-in connectors. Communications links to clients 108-112 in Figure 1 may be provided through modem 218 and network adapter 220 connected to PCI local bus 216 through add-in boards.

Additional PCI bus bridges 222 and 224 provide interfaces for additional PCI local buses 226 and 228, from which additional modems or network adapters may be supported. In this manner, data processing system 200 allows connections to multiple network computers. A memory-mapped graphics adapter 230 and hard disk 232 may also be connected to I/O bus 212 as depicted, either directly or indirectly.

Those of ordinary skill in the art will appreciate that the hardware depicted in Figure 2 may vary. For example, other peripheral devices, such as optical disk drives and the like, also may be used in addition to or in place of the hardware depicted. The depicted example is not meant to imply architectural limitations with respect to the present invention.

The data processing system depicted in Figure 2 may be, for example, an IBM e-Server pSeries system, a product of International Business Machines Corporation in Armonk, New York, running the Advanced Interactive Executive (AIX) operating system or LINUX operating system.

Docket No. AUS920030292US1

With reference now to **Figure 3**, a block diagram illustrating a data processing system is depicted in which the present invention may be implemented. Data processing system 300 is an example of a client computer. Data processing system 300 employs a peripheral component interconnect (PCI) local bus architecture. Although the depicted example employs a PCI bus, other bus architectures such as Accelerated Graphics Port (AGP) and Industry Standard Architecture (ISA) may be used.

Processor 302 and main memory 304 are connected to PCI local bus 306 through PCI bridge 308. PCI bridge 308 also may include an integrated memory controller and cache memory for processor 302. Additional connections to PCI local bus 306 may be made through direct component interconnection or through add-in boards.

In the depicted example, local area network (LAN) adapter 310, SCSI host bus adapter 312, and expansion bus interface 314 are connected to PCI local bus 306 by direct component connection. In contrast, audio adapter 316, graphics adapter 318, and audio/video adapter 319 are connected to PCI local bus 306 by add-in boards inserted into expansion slots. Expansion bus interface 314 provides a connection for a keyboard and mouse adapter 320, modem 322, and additional memory 324. Small computer system interface (SCSI) host bus adapter 312 provides a connection for hard disk drive 326, tape drive 328, and CD-ROM drive 330. Typical PCI local bus implementations will support three or four PCI expansion slots or add-in connectors.

Docket No. AUS920030292US1

An operating system runs on processor 302 and is used to coordinate and provide control of various components within data processing system 300 in **Figure 3**. The operating system may be a commercially available operating system, such as Windows 2000, which is available from Microsoft Corporation. An object oriented programming language such as Java may run in conjunction with the operating system and provide calls to the operating system from Java programs or applications executing on data processing system 300. "Java" is a trademark of Sun Microsystems, Inc. Instructions for the operating system and applications or programs are located on storage devices, such as hard disk drive 326, and may be loaded into main memory 304 for execution by processor 302.

Those of ordinary skill in the art will appreciate that the hardware in **Figure 3** may vary depending on the implementation. Other internal hardware or peripheral devices, such as flash ROM (or equivalent nonvolatile memory) or optical disk drives and the like, may be used in addition to or in place of the hardware depicted in **Figure 3**. Also, the processes of the present invention may be applied to a multiprocessor data processing system.

As another example, data processing system 300 may be a stand-alone system configured to be bootable without relying on some type of network communication interface, whether or not data processing system 300 comprises some type of network communication interface. As a further example, data processing system 300 may be a personal digital assistant (PDA) device, which is configured with

Docket No. AUS920030292US1

ROM and/or flash ROM in order to provide non-volatile memory for storing operating system files and/or user-generated data.

The depicted example in **Figure 3** and above-described examples are not meant to imply architectural limitations. For example, data processing system **300** also may be a notebook computer or hand held computer in addition to taking the form of a PDA. Data processing system **300** also may be a kiosk or a Web appliance.

With reference now to **Figure 4**, a block diagram illustrating a database configuration with an XML interface is shown in accordance with a preferred embodiment of the present invention. Server **420** provides data and services to client **410**. More specifically, client **410** may access database **424** using XML interface **412**. API **414** receives XML requests from the client and generates XML response documents that may return data from the database, or notification that an update was successful. The XML requests may include, for example, Lists, Gets, Deletes, Updates, or Adds.

In accordance with a preferred embodiment of the present invention, the architecture team for the configuration develops data dictionary **422**, which specifies the entities and corresponding attributes for API **414** to use. The server also includes utility classes that correspond to the entities that are defined in the data dictionary. Each utility class defines utility methods for use in retrieving data. In a Java implementation the utility methods may be, for example, public, static methods. In the example shown in **Figure**

Docket No. AUS920030292US1

4, utility class 432 defines utility method 434 and utility class 436 defines utility method 438.

In the depicted example, API 414 calls utility method 434. The utility method generates and returns a response object. In a preferred embodiment, the response object is an XML document. By returning the response as an object, the schema developers can generate Java classes (with setter and getter methods) that correspond to the elements they define in the schemas. In developing XML responses, the API developers can use these response objects to connect child XML elements to parents. Also, functionality is available that obtains a string representation of the response object to see what the XML actually looks like. The API can then append the response at the depth necessary in order to generate an XML document to return to XML interface 412.

Depending on the API, the XML response might only need to include a subset of data that may be returned. For example, a method call may pass an ArrayList of String objects denoting attributes the client requests to have returned. The server includes structured query language (SQL) interface 426, which receives SQL statements, which may be dynamically generated by utility methods 434, 438. The utility methods may then retrieve data from database 424 using SQL interface 426 and generate the appropriate XML response object to be returned.

With reference now to Figure 5, an example implementation is shown in accordance with a preferred embodiment of the present invention. Server 520 provides

Docket No. AUS920030292US1

data and services to client 510. More specifically, client 510 may access database 524 using XML interface 512. API 514 receives XML requests from the client and generates XML response documents that may return data
5 from the database. The XML requests may include, for example, Lists, Gets, Deletes, Updates, or Adds.

Examples of an API may include ListServers, ListUsers, AddCustomer, UpdateSoftwareSpecification, or DeleteServerGroup. The XML response documents may return
10 the data from the database, along with an error code, or simply return the error code, a response description, and a record confirmation, in the case of deletes, updates, or adds.

Data dictionary 522 specifies the entities and
15 corresponding attributes for API 514 to use. Examples of entities may include Customer, User, IPAddress, Storage Allocation, ObjectPermissions, Status, etc. Examples of the attributes of Customer may include its ID, which is of type Integer; its Name, LongName, and Description,
20 which are of type String; its CustomerObjectPermissions, which is of type ObjectPermissions (a defined entity); and its CustomerStatus, which is of type Status (a defined entity). An example of an XML response that the client wishes to have returned is shown as 502.

25 A first utility class, StatusBean 532, defines a utility method, getStatus() 534. A second utility class, ObjectPermissionsBean 536, defines a utility method, getObjectPermissions() 538. The StatusBean class is only concerned only with retrieving information about the
30 Status entity. As a result, in its getStatus() method,

Docket No. AUS920030292US1

it takes a status ID (the ID of the entity) and a String representing the XML element name that the caller of the class wants the XML response object's name to be. The `getStatus()` method takes the XML element name, because
5 although multiple entities may make use of one utility class, they may want to have different names for it in the generated XML response. For example, the Customer entity may call its Status entity "Customer Status," the User entity may call it "UserStatus," and the IPAddress
10 entity may simply call it "Status."

In the depicted example, API 514 calls `getStatus()` 534 and passes the entity ID, the response object name, "CustomerStatus," and an empty list of attributes. An empty list of attributes causes the utility method return
15 every possible attribute for the entity. The utility method, `getStatus()`, generates and returns an XML response object, CustomerStatus. The `getStatus()` method may obtain the appropriate attributes for the Customer entity using SQL interface 526. The API then appends the
20 returned factory object at the appropriate depth so that XML response 502 is generated correctly. For example, in the example XML response shown as 502, the API appends the CustomerObjectPermissions entity after the CustomerStatus entity.

25 Depending on the API, the XML response might only need to include a subset of data that may be returned. For example, the method call may pass an ArrayList of String objects denoting attributes, such as "ID" for only the ID of the Status entity. In this example, the
30 `getStatus()` method generates a SQL statement to retrieve

Docket No. AUS920030292US1

the ID attribute for the Status entity from database 524 using SQL interface 526. The getStatus() method would then generate the appropriate XML response object to be returned.

5 **Figure 6** is a flowchart illustrating the maintenance of an entity in a database infrastructure in accordance with a preferred embodiment of the present invention. The process begins and the architecture team develops a specification for an entity in the data dictionary (step
10 **602**). The developer codes static utility methods to return data for the entity (step **604**).

A determination is made as to whether the specification has changed for the entity (step **606**). If the specification for the entity has not changed, the
15 process ends. If, however, the specification for the entity has changed in step **606**, the utility owner changes the internal method implementation (step **608**) and the process ends. Having the entity encapsulated as a class with an associated utility method allows the developer to
20 only have to change the utility, rather than all the APIs that use the entity.

With reference now to **Figure 7**, a flowchart illustrating the operation of an application program interface is shown in accordance with a preferred
25 embodiment of the present invention. The process begins when an XML request is received. Responsive to the request, the application program interface calls a static utility method (step **702**) and receives a response object populated with the required or specified data for an
30 entity (step **704**). The application program interface

Docket No. AUS920030292US1

then appends the object at the appropriate depth for the XML response (step 706). Then, the application program interface marshals the object into an XML string to return to the XML client (step 708) and the process ends.

5 Turning now to **Figure 8**, a flowchart illustrating the operation of a utility method is shown in accordance with a preferred embodiment of the present invention. The process begins and receives a method call (step 802). The utility method identifies an entity (step 804) and
10 identifies data to return (step 806). Then, the utility method receives the requested data (step 808) and generates the XML response object (step 810). Thereafter, the utility method returns the XML response object (step 812) and the process ends.

15 Thus, the present invention solves the disadvantages of the prior art by providing a set of classes that define utility methods for use in retrieving data. Application program interfaces may call these utility methods, passing an identification of an entity and a
20 string representing extensible markup language element name that the caller wants the extensible markup language response object's name to be and also passing a list of the attributes or an empty string for all attributes for the entity. When a change is made to an entity, only the
25 code in the utility methods must be updated, rather than in every area that the entity is used. This greatly improves the productivity of developers. Another advantage is the flexibility that this approach offers. The attributes returned by a utility method may be

Docket No. AUS920030292US1

determined by the identified entity or by the application program interface.

It is important to note that while the present invention has been described in the context of a fully functioning data processing system, those of ordinary skill in the art will appreciate that the processes of the present invention are capable of being distributed in the form of a computer readable medium of instructions and a variety of forms and that the present invention applies equally regardless of the particular type of signal bearing media actually used to carry out the distribution. Examples of computer readable media include recordable-type media, such as a floppy disk, a hard disk drive, a RAM, CD-ROMs, DVD-ROMs, and transmission-type media, such as digital and analog communications links, wired or wireless communications links using transmission forms, such as, for example, radio frequency and light wave transmissions. The computer readable media may take the form of coded formats that are decoded for actual use in a particular data processing system.

The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for

Docket No. AUS920030292US1

various embodiments with various modifications as are suited to the particular use contemplated.